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memorandum

Environment and Resources
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Date	March 15, 2011
To	Ashley Allen, Jason Berner, U.S. Environmental Protection Agency (EPA)
From	Emily Giovanni, Lauren Parker, and Elena Besedin, Abt Associates Inc.
Subject	Distance Downstream of Urban Stormwater Impacts

Very few studies directly examine the question of how far downstream the impacts of urban stormwater occur. Most longitudinal studies instead measure impacts of urban areas compared with other types of land uses, and only look at impacts to a certain distance away from urban areas. As such, the distance downstream of impacts observed in these studies represent a minimum, since there may be additional impacts further downstream than the most distant observation. Additionally, many of the studies aimed at comparing urban land uses to other types benefit from comparing water quality upstream of urban areas to that inside urban areas. Therefore, there is a relative dearth of data documenting how far downstream impacts of urban runoff are observable.

Even if studies generating data on downstream water quality were more widely available, several factors make it difficult to identify a cutoff point for impacts. These include:

- Anthropogenic causes of impacts do not stop at the end of urban designations. Roads, houses, gas stations, and other entities downstream from urban areas may also contribute to runoff to streams, making attribution to urban areas increasingly difficult. For example, road salts applied in rural areas downstream of urban areas can significantly affect water quality, especially since they are often applied in higher concentrations on more rural roads (Cunningham, et al., 2009).
- Temporal factors can strongly influence the degree of impacts observed. For example, stream widening as a result of urban stormwater runoff occurs over time, often many years after urbanization. Harvey and Morris (2004) noted continually increasing erosion impacts at sites downstream from development over several decades post-development, and Keen-Zebert (2007) found evidence that there is an overall net decrease in channel depth in urban areas that are more than 20 years old.
- Many site-specific characteristics influence the degree and distance of impacts. Among many others, examples include:
    - Gregory et al. (1992) found that channel capacities downstream from urban areas are clearly higher than other areas (such as in rural areas upstream of urban areas), but that there was no consistent degree of increase. The authors note that a possible reason for this variability is that the basin overlies chalk in the headwater areas and tertiary rocks in the middle and lower reaches.
    - Similarly, Booth (1990) found that channel slope and geologic material are particularly critical in determining the extent of channel incision.

Despite these challenges, we identified several studies employing longitudinal data that provide some insight into how far downstream impacts can occur, including Cunningham, et al. (2009), Mallin, et al. (2009), Harvey and Morris (2004), and Gregory, et al. (1992). As noted above, these studies examined impacts of urbanization on stream water quality or morphology, and limited their longitudinal data to certain distances away from the urban areas. As such, the distance downstream of impacts should not be interpreted as definitive or even average; in most cases, they should be viewed as minimums, since impacts are likely to occur beyond the geographical scope of the studies.

Cunningham, et al. (2009) looked at the impacts of impervious surface cover on chloride and nitrate levels in headwater streams in the Hudson River watershed in New York, within and downstream of urban areas. They found that concentrations of both pollutants increased according to impervious surface, and that per-capita inputs were significantly higher in rural areas compared with urban areas. We overlaid a GIS layer of census designated urban areas, and measured the distance downstream from urban areas to the authors' study sites. The study site furthest downstream of the urban areas was approximately 30 km (or 18 miles) downstream from designated urban areas, and the authors' results showed that the effects were observable there.

Mallin, et al. (2009) looked at the effects of impervious cover on biochemical oxygen demand (BOD), phosphorus, surfactant, and total organic carbon (TOC) in Prince George's Creek in North Carolina. They found that BOD, surfactant, and phosphorus concentrations were all positively correlated with impervious surface, while TOC was negatively correlated. Three sites showing impacts were located downstream of designated urban areas, with the most distant being about 2 km (1.24 miles) downstream.

Harvey and Morris (2004) studied the Fountain Creek watershed within the Arkansas River Basin in Colorado, which has experienced a high degree of erosion and flooding in urbanized areas (the City of Colorado Springs) and downstream. For example, the Greenview site, which is approximately 32 km (20 miles) downstream of designated urban areas, has experienced increased frequencies of peak flows and increased flow volume. Between 1955 and 1999, the bank at that site retreated about 60 meters, with various magnitudes of retreat coinciding with incidences of floods. The authors estimate that upstream development caused a 26% increase in flood peak, a 33% increase in flow volume, and a 17.5% increase in flow velocity, all contributing to erosion.

Gregory, et al. (1992) looked at the impacts of upstream urbanization on river channels in the Monks Brook drainage basin in England, using historical methods as well as site-specific measurements. They found vegetation indicators of channel enlargement 800 meters (875 yards) downstream.

Sources

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